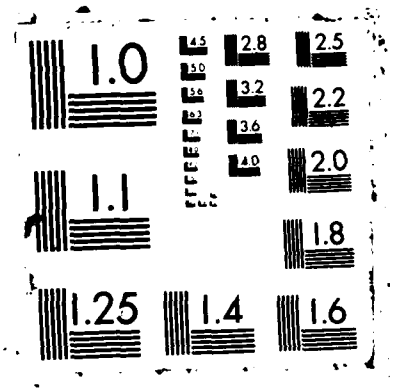
AD-A183 457 WATER SOLUBLE CORROSION INHIBITORS TO PROTECT IMMERSED STEEL AND ALUMINUM(U) ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENGINEERING CENTER DOV.. H HARTMANN 1/1

UNCLASSIFIED JUL 87 ARPAD-MR-87001 F/G 11/6.1 NL

END
9-87
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
7.1
8.0
9.0
10.0

(12)

AD

AD-E401 720

MEMORANDUM REPORT ARPAD-MR-87001

WATER SOLUBLE CORROSION INHIBITORS TO PROTECT IMMERSED STEEL AND ALUMINUM

HENRY HARTMANN

JULY 1987

US ARMY
ARMAMENT MUNITIONS
& CHEMICAL COMMAND
ARMAMENT RDE CENTER

U. S. ARMY ARMAMENT, MUNITIONS AND CHEMICAL COMMAND
PRODUCT ASSURANCE DIRECTORATE
PICATINNY ARSENAL, NEW JERSEY

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement by or approval of the U.S. Government.

Destroy this report when no longer needed by any method that will prevent disclosure of contents or reconstruction of the document. Do not return to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: MEMORANDUM REPORT ARPAD-MR-87001	2. GOVT ACCESSION NO.: A183457
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: WATER SOLUBLE CORROSION INHIBITORS TO PROTECT IMMERSED STEEL AND ALUMINUM	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Henry Hartmann	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: AMCCOM (D), PAD Technology Office [AMSMC-QAH-T(D)] Picatinny Arsenal, NJ 07806-5000	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: ARDEC, IMD STINFO Division (SMCAR-MSI) Picatinny Arsenal, NJ 07806-5000	12. REPORT DATE: July 1987 13. NUMBER OF PAGES: 17
14. MONITORING AGENCY NAME & ADDRESS*(If different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: Unclassified 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Corrosion	Sodium nitrite
Inhibitor	Sodium silicate
Steel	Silicon dioxide
Aluminum	Rust
Water	Ultrasonic testing

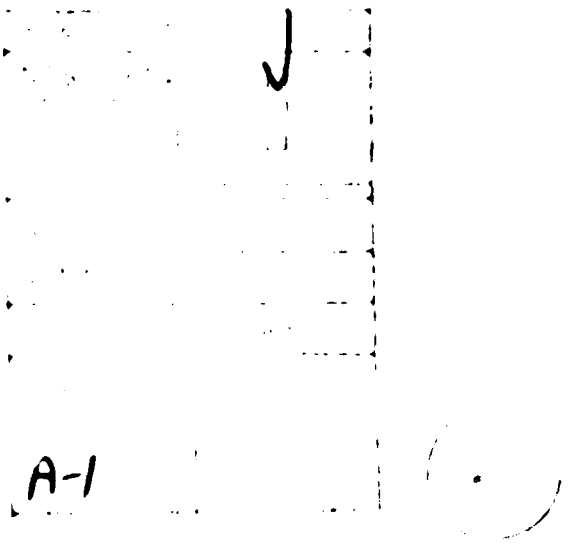
20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The water soluble corrosion inhibitors to protect immersed steel and aluminum metal parts in dilute concentrations of sodium nitrite and silicon dioxide (the active ingredient of sodium silicate) separately provide complete rust and corrosion protection for at least three days.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

CONTENTS



INTRODUCTION

Much of the nondestructive test (NDT) work at Picatinny Arsenal involves ultrasonic testing under water. A corrosion inhibitor is dissolved in the holding tank water to protect all the metal in the tank structure as well as any metal placed within. In question is the proper concentration of corrosion inhibitor to provide complete protection of all immersed metal. At times technicians have thrown in a handful or half a cup of corrosion inhibitor without bothering to figure out the proper amount. The purpose of this report is to evaluate the effectiveness of two common corrosion inhibitors, sodium nitrite and sodium silicate, and to determine minimum concentrations of each in distilled water for complete protection of immersed steel and aluminum.

TEST DESIGN

Metals

Since most of the materials placed into our ultrasonic test tank are high strength steel and high strength aluminum, these are the two metals to be evaluated for corrosion protection. However, the shape the metal samples should be in is a problem. Investigation revealed that steel wool is an excellent material for revealing corrosion. It was decided to insert a good size ball of steel wool into a 5-oz plastic cup about three quarters full of water for a period of 3 days. About three quarters of the steel wool was submerged in water with the remaining quarter above the water surface.

Creating an aluminum sample was more difficult. Aluminum foil was tried but the finely finished surfaces resisted corrosion. Finally, a forged BASE from a 155-mm carrier projectile was taken to the machine shop and 1.6 mm (0.062 in.) thick chips were sheared from the BASE on a shaper metal working machine. The chips were curled with one surface crimpled while the opposite surface was bright. The material was high strength aluminum alloy 7075-T6. One chip was completely submerged in a 5-oz plastic glass.

Corrosion Inhibitors

A previous report[1] revealed that the most commonly used inhibitors for years have been sodium nitrite and sodium silicate. These inhibitors were selected for trial as both metals in metal-to-metal contact tests. There are a number of commercially available, specially compounded inhibitors that claim to protect both metals. Sodium nitrite is usually used in these solutions. For example, Dowtherm 185 is a sodium nitrite base inhibitor, which

[1] Hartman, Dennis, "Test Site Inhibitors," Technical Report, Picatinny Arsenal, Dover, N.J., 1974.

Concentration in Distilled Water

It was decided to measure by cubic centimeters both the corrosion inhibitors and distilled water. In this way, mixing various concentrations will be simple. It was also planned to start with a maximum concentration of 0.01, that is, one volume of corrosion inhibitor dissolved in 100 volumes of distilled water. Concentrations decreased in equal steps starting from 0.01 to 0.005, 0.001, 0.0005, 0.0001, 0.00005, and finally 0.00001.

To obtain one unit volume of silicon dioxide (this is the active corrosion inhibitor in sodium silicate), six volumes of liquid sodium silicate (water glass) grade 40 are required. The composition of liquid sodium silicate is listed in table 1. Solid silicon dioxide (pure sand) is an abrasive; however, when molecularly combined with sodium oxide, it becomes water soluable and is an excellent corrosion inhibitor.

Findings

All of the corrosion inhibitor data are listed in table 2. Many of the tests were repeated twice. The following results were obtained:

1. Some of the corrosion inhibitors were effective at very dilute concentration.

2. No corrosion took place on steel wool that rose above the level of water containing corrosion inhibitors. On some of the strands of steel wool, thin outlines of salt were evident.

CALCULATION FOR THE AMOUNT OF CORROSION INHIBITOR NEEDED

[illegible] pints per gallon, 16 fluid ounces per pint, 2 tablespoons per fluid ounce, and 3 teaspoons per tablespoon, then there are 768 teaspoons per [illegible].

Protecting Steel

[illegible]

[illegible] gallons of water, [illegible] teaspoons [illegible] sodium nitrite.

[illegible] corrosion inhibitor.
[illegible].

0.00050 silicon dioxide
t = 0.00050 (768) 6 g

For example: For 30 gallons of water, t = 0.00050 (768) 6 (30) = 69.1 teaspoons or 1.4 cups of sodium silicate.

Protecting Aluminum

0.00001 sodium nitrite
t = 0.00001 (768) g

For example: For 30 gallons of water, t = 0.00001 (768) 30 = 0.2 teaspoon of sodium nitrite.

0.00001 silicon dioxide
t = 0.00001 (768) 6 g

For example: for 30 gallons of water, t = 0.00001 (768) 6 (30) = 1.4 teaspoons of sodium silicate.

EFFECT UPON THE SPEED OF SOUND

Additives to distilled water can affect the speed of sound. A measuring cylinder graduated to 25 cm^3 was used to hold either distilled water or corrosion inhibiting solutions, and the time was measured for an ultrasound pulse to pass down through the liquid and bounce back up. The total distance of passage was 37.5 cm (14.8 inches). The estimate for error is 0.001. Time measurements were made on a cathode ray tube screen using distilled water for the calibration checks before and after each of the two tests:

Liquid	Time, cm
Distilled water	10.00
0.01 sodium nitrite solution	10.00
Distilled water	10.00
0.06 sodium silicate solution	9.95
Distilled water	10.00

The concentrations of both corrosion inhibitors were the maximum that were tried. Sodium nitrite had no affect on the speed of sound. Sodium silicate permitted the speed of sound to increase by 1/2 of 1%. Since this increase in speed is probably a linear function, at a concentration of 0.00001 (as compared to 0.01), the increase in the speed of sound should be a negligible 0.0005%. To verify this, the following data were obtained:

Liquid	Time, cm
Distilled water	10.00
0.00006 sodium silicate solution	10.00
Distilled water	10.00

It was observed that substantial ultrasonic noise appeared with the presence of either corrosion inhibitor. This is the sacrifice in ultrasonic signal-to-noise ratio when either corrosion inhibitor is used. However, in actual use, dilute concentrations of corrosion inhibitor should cause little impact upon the ultrasonic signal-to-noise ratio.

COST CALCULATIONS

If purchased in 55 gallon drum quantities, the basic cost of granular sodium nitrite is about $25 per gallon; whereas, liquid sodium silicate costs about $2 per gallon. However, Grade 40 degrees sodium silicate contains only 1/6 silicon dioxide by volume; therefore, silicon dioxide costs about $12 per gallon (6 x 2).[3]

Protecting steel submerged in 100 gallons of water:

Sodium nitrite, (0.00005) $25 (100 gallons) = 13¢

Silicon dioxide, (0.0005) $12 (100 gallons) = 60¢

Protecting 7075-T6 aluminum submerged in 100 gallons of water:

Sodium nitrite, (0.00001) $25 (100 gallons) = 3¢

Silicon dioxide, (0.00001) $12 (100 gallons) = 1¢

CONCLUSIONS

1. Both sodium nitrite and silicon dioxide (the active ingredient of sodium silicate) are very effective in preventing corrosion of steel and high strength aluminum alloy #7075-T6 while immersed in water for three days. Minimum concentrations of each corrosion inhibitor for complete protection and the cost of each in 100 gallons of water are:

[3]All money in this report is in FY87 dollars.

	Portion in water by volume		Cost in 100 gal. of water ($)	
Metal	Sodium nitrite	Silicon dioxide	Sodium nitrite	Silicon dioxide
Steel wool	0.00005	0.00050	0.12	0.60
7075-T6 aluminum	0.00001	0.00001	0.03	0.01

2. The presence of either corrosion inhibitor at the minimum recommended rates has no significant impact on the speed of sound through the solution.

3. An attractive bronze coating can be obtained over bare aluminum by soaking in a 1% sodium nitrite solution (by volume) for three days.

Table 1. Composition of liquid sodium silicate, grade 40*

	Sodium oxide (Na_2O)	Silicon dioxide (SiO_2)	Water (H_2O)
Portion by weight	0.091	0.292	0.617
Specific gravity	2.27	2.32	1.0
Portion by volume	0.05	0.16	0.79

*"Grades of Diamond Liquid Sodium Silicates," Diamond Shamrock Chemicals Co., Technical Bulletin, Painesville, OH, 1985.

Table 2. Effect of two inhibitors on the corrosion of steel and alumin

Portion by volume of inhibitor in water	Sodium nitrite ($NaNO_2$)	Silicon dioxide (SiO_2)
		Steel Wool
0.01	No corrosion	No corrosion
0.005	No corrosion	No corrosion
0.001	No corrosion	No corrosion
0.0005	No corrosion	No corrosion
0.0001	No corrosion	Localized dark brown r of surface
0.00005	No corrosion	Localized dark brown r of surface
0.00001	Slight rusting	Localized rust near su about 0.01% of surface
0.00000 (pure water)	Mostly amber but some black rust covering 100 percent of the steel wool su	
		Aluminum alloy 7075-T6 chips
0.01	No corrosion, microscopic patches of bronze color covering half the surface; overall appearance is a silvery bronze	No corrosion
0.005	No corrosion, lighter bronzing color than above	No corrosion
0.001	No corrosion, barely perceptible bronzing	No corrosion
0.005	No corrosion, barely perceptible bronzing	No corrosion
0.0001	No corrosion, barely perceptible bronzing	No corrosion
0.00005	No corrosion, no bronzing	No corrosion
0.00001	No corrosion, no bronzing	No corrosion
0.00000 (pure water)	Corrosion consists of considerable hydroxide gel plus many black spots cove	

rrosion of steel and aluminum while immersed in water for three days

Silicon dioxide (SiO_2)	Combined equal portions of sodium nitrite + silicon dioxide
Steel Wool	
No corrosion	No corrosion
No corrosion	No corrosion
No corrosion	No corrosion
No corrosion	No corrosion
Localized dark brown rust over about 0.25% of surface	Two localized rust spots just beginning
Localized dark brown rust over about 0.25% of surface	Very, very light rust covering 100% of surface
Localized rust near surface of water covering about 0.01% of surface	Very light rusting covering 100% of surface

percent of the steel wool surface

luminum alloy 7075-T6 chips

lor is	No corrosion	No corrosion, no bronzing
e	No corrosion	No corrosion
	No corrosion	No corrosion, no bronzing
	No corrosion	No corrosion, no bronzing
	No corrosion	No corrosion, no bronzing
	No corrosion	No corrosion, no bronzing
	No corrosion	No corrosion, no bronzing
	No corrosion	No corrosion, no bronzing

el plus many black spots covering the rough surface, bright surface unscathed

DISTRIBUTION LIST

Commander
Armament Research, Development
and Engineering Center
U.S. Army Armament, Munitions
and Chemical Command
ATTN: SMCAR-MSI (5)
SMCAR-AEE
SMCAR-AEF
SMCAR-ASM
SMCAR-CCH
SMCAR-FSA
SMCAR-FSM
SMCAR-FSN
SMCAR-FSP
SMCAR-FSS
Picatinny Arsenal, NJ 07806-5000

Commander
U.S. Army Armament, Munitions
and Chemical Command
ATTN: AMSMC-GCL (D)
AMSMC-QAA (D)
AMSMC-QAF (D)
AMSMC-QAH (D)
AMSMC-QAN (D)
AMSMC-QAR (D)
AMSMC-QAT (D)
AMSMC-QAU (D)
Picatinny Arsenal, NJ 07806-5000

Administrator
Defense Technical Information Center
ATTN: Accessions Division (12)
Cameron Station
Alexandria, VA 22304-6145

Director
U.S. Army Materiel Systems
Analysis Activity
ATTN: AMXSY-MP
Aberdeen Proving Ground, MD 21005-5066

Commander
Chemical Research, Development
and Engineering Center
U.S. Army Armament, Munitions
and Chemical Command
ATTN: SMCCR-MSI
Aberdeen Proving Ground, MD 21010-5423

Commander
Chemical Research, Development
and Engineering Center
U.S. Army Armament, Munitions
and Chemical Command
ATTN: SMCCR-RSP-A
AMSMC-QAC (A)
AMSMC-QAE (A)
AMSMC-QAO (A)
Aberdeen Proving Ground, MD 21010-5423

Director
Ballistic Research Laboratory
ATTN: AMXBR-OS-ST
Aberdeen Proving Ground, MD 21005-5066

Chief
Benet Weapons Laboratory, CCAC
Armament Research, Development
and Engineering Center
U.S. Army Armament, Munitions
and Chemical Command
ATTN: SMCAR-CCB-TL
Watervliet, NY 12189-5000

Commander
U.S. Army Armament, Munitions
and Chemical Command
ATTN: SMCAR-[illegible]
SMCAR-[illegible]
SMCAR-[illegible]
SMCAR-ESW
Rock Island, IL 61299-5000

Director
U.S. Army TRADOC Systems
Analysis Activity
ATTN: ATAA-SL
White Sands Missile Range, NM 88002

Commander
U.S. Army Armament, Munitions
and Chemical Command
ATTN: AMSMC-QAD
AMSMC-QAG
AMSMC-QAI
AMSMC-QAK
AMSMC-QAL
AMSMC-QAM
AMSMC-QAS
AMSMC-QAV
AMSMC-QAW
Rock Island, IL 61299-6000

Commander
Lone Star Army Ammunition Plant
ATTN: SMCLS-QA
Texarkana, TX 75505-9100

Commander
Longhorn Army Ammunition Plant
ATTN: SMCLO-QA
Marshall, TX 75670

Commander
Louisiana Army Ammunition Plant
ATTN: SMCLA-QA
Shreveport, LA 71130

Commander
McAlester Army Ammunition Plant
ATTN: SMCMC-QA
McAlester, OK 74501

Commander
Milan Army Ammunition Plant
ATTN: SMCMI-QA
Milan, TN 38358

Commander
U.S. Army Pine Bluff Arsenal
ATTN: SMCPB-QA
Pine Bluff, AR 71602-9500

Commander
Red River Army Ammunition Plant
ATTN: SARRI-QA
Texarkana, TX 75501

Commander
U.S. Army Research and
Technology Laboratories
ATTN: DAVDL-EU
Fort Eustis, VA 23604

Director
U.S. Army Research and Technology
Laboratories
AMES Research Center
ATTN: DAVDL-AS
Moffett Field, CA 94035

Director
U.S. Defense Ammunition Center
and School
ATTN: SARAC-DE
Savanna, IL 61074

Commander
Iowa Army Ammunition Plant
ATTN: SMCIO-A
Middletown, IA 52638

Commander
Kansas Army Ammunition Plant
ATTN: SMCKA-A
Parsons, KS 67357

Commander
Lone Star Army Ammunition Plant
ATTN: SMCLS-A
Texarkana, TX 75501

Commander
U.S. Army Materiel Command
ATTN: AMCDE-SA
5001 Eisenhower Avenue
Alexandria, VA 22333

Commander
U.S. Army Armament Materiel Readiness Command
ATTN: DRSAR-ASF
Rock Island, IL 61299

Commander
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSAR-ASF
Rock Island, IL 61299

Commander
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSAR-SF
Rock Island, IL 61299

Commander
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSAR-IMI-I
Rock Island, IL 61299

Commander
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSAR-QAC-E
Rock Island, IL 61299

Commander
U.S. Navy Weapons Station
ATTN: Code 33
Concord, CA 94520

END

9-87

DTIC